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THE TRADITION OF PHYSICAL MEDICINE

By JAMES MENNELL

WHEN I was first asked to contribute a paper on the Tradition of Physical Medicine, I accepted the challenge without hesitation, as it seemed a comparatively easy task. This was because I had made the not uncommon mistake of identifying tradition with history. The latter treats generally, but factually, of human activity in a given sphere; the former is nebulous and often speculative—in a word, unhistorical yet part of history. Established facts (of history) are unalterable, but not so their interpretation nor the traditions which have been built upon them.

The first question that comes to mind is, Can Physical Medicine, as we understand it to-day, have a tradition of its own, seeing that there was a time within living memory when the two words were not found in conjunction? On reflection, however, it is clear that Physical Medicine has indeed a tradition, a tradition, moreover, which is lost in antiquity, for its history is coextensive with human existence. Much is instinctive and not confined to the human race; witness the cat or dog which rhythmically licks a damaged paw, and which, on waking from sleep, invariably takes a full breath, yawns, and stretches.

In my search for the early origins of our Tradition, three works from which inspiration so often comes—the Bible, Shakespeare, and the *Ingoldsby Legends*—failed to help me. I next turned to two old favourites of mine: Sir Arthur Keith's *Menders of the Maimed*, published in 1919, and Graham's *Massage*, first published in 1890. Both, however, deal mainly with History rather than with the Tradition that inspired it; I shall, nevertheless, return to Sir Arthur Keith's work later. Then fortune favoured me when I read in *The Times* of July 5, 1952, an article

from "a correspondent" entitled "The Conquest of Frustration". It runs thus: "'So little done, so much to do'—the last words of Cecil Rhodes express succinctly the feeling of incompletion, mounting often to frustration, which is experienced by many in the modern world. It can be the feeling especially of men and women who are occupied in good works, who are imaginatively aware of the needs of others and try to meet them, and who try to love their neighbours as themselves. There are multitudinous opportunities of service; to use one is to leave many unused." For those who, like ourselves, are pioneers in a new branch of medical science it would be difficult to find a better tradition on which to found our present and future tasks.

Looking back after forty years of interest in physical medicine, and while of course agreeing with Cecil Rhodes, I refuse to accept his words entirely, despite feelings of frustration I may have had in the past. I prefer with thankfulness to join with the "Village Blacksmith" in the feeling that "something attempted, something done" is the tradition that should govern our future. We must not, however, follow the "Blacksmith" any further, for he continues with the words: "has earned a night's repose". There can be no "repose" for those who follow, for unless we progress our branch of medical science will inevitably perish.

Now to return to Sir Arthur Keith's remarkable book. The preface begins as follows: "Men of business find it necessary, from time to time, to take an inventory of the goods they have in stock; occasions arise when medical men must do the same thing and make a survey of the means of treatment at their disposal." The book was written to restate the principles which underlie the art of orthopaedic surgery. His history begins in 1728 with the orthopaedic principles of John Hunter; he then turns to those of John Hilton and Hugh Owen Thomas. On closing the book, one thought is left outstanding—namely, that the greatest danger besetting any scientific writer is the creation of false antitheses.

Two great principles evolve from the history of orthopaedics: treatment by rest and treatment by movement. These two have been regarded as incompatible contrasts and thus a false antithesis has been created. We have to go back much further than did Sir Arthur Keith; in fact, to Aristotle, who taught that "Movement is Life". It is true that he did not preach the corollary that immobilization is death, but it needs must be the end, if only for the time being, of all function. Here, then, is at least one basic principle on which physical medicine may well be founded—namely, that it is better to maintain function than to restore it after it has been lost.

Our next task is to correct the false antithesis by which we are confronted. There are those who insist in placing white and black in sole and complete opposition, without regard for intervening shades. To them spades are spades, but they are apt to forget that truth may be lost in the clatter of tools. The tendency of the Hunter–Hilton school was to concentrate on

treatment by rest, by which they meant immobilization: that was white, and therefore the only treatment resulting from enlightened thought, while treatment by movement was anathema, black and unholy. The possibility that both might be of service we owe to Lucas-Championnière, whose genius suggested to him the possibility of distinguishing between rest from movement and rest from function. Roughly speaking, his principle was that movement was antagonistic to recovery only if accompanied by pain, and that painless movement should be used as a potent influence for the restoration of lost function and for preserving the possibilities of function against the time when it may safely be resumed. As an aid to the maintenance or restoration of painless movement he advocated the use of sedative massage.

Thus we come to the tradition of massage. It is worthy of note that we find repeated references to massage throughout the history of various civilizations; for instance, Egypt, Greece, and Rome. So, too, it would appear that at regular intervals it has fallen into disuse. Massage has, however, never died out altogether, and indeed it seems probable that it never will, as it is natural and, I think, intuitive. Why, then, should the traditional use of massage have had such a varied history? On this point we can only judge by the result of comparatively recent experience, which is probably a repetition of previous episodes in history. Like all good and useful remedies, it is the one, *par excellence*, that can be too easily abused. Moreover, the claims made for it have tended to become fantastic, and its practice, therefore, has been followed by disrepute.

At the time of writing the use of massage is largely under a cloud, mainly because the introduction of so-called Swedish massage failed to secure many of the benefits that were claimed for it; massage, however, remains a recognized feature of spa practice. It is a traditional duty of Physical Medicine to determine the value of massage and to dispute claims which are without scientific foundation.

We now come to another form of treatment—namely, by manipulation. In this country from time immemorial—certainly long before medical treatment began to assume its present place—there existed, particularly in the North Country, individuals who were known as "bone-setters". There seems to have been a definite tradition that in certain families there should be at least one member to whom his fellows could apply for help when suffering from disability in the limbs. It is quite wrong to say that these men were untrained: their training was not scientific and their knowledge of the laws of anatomy and physiology was conspicuously lacking, but the fact remained that they were often successful in bringing relief when orthodox treatment failed. Accidents, of course, occurred, many of them serious, but the element of success was undoubtedly present. The technique of this form of treatment was handed down as a close secret from generation to generation. Though no doubt it was applied only to the limbs in earlier

days, a similar method was later applied to the spine, and the art of osteopathy established itself. This has been followed by other forms of manipulative treatment, the most notable being chiropraxis. Unfortunately, all these forms of treatment were lacking in scientific background. It was only after the introduction of radiographic examination of bones and joints that a true explanation of what to do and how to do it became possible. In the medical world there have been many outstanding men who have preached the value of, and practised, manipulation; and it must be remembered that Hugh Owen Thomas, of Liverpool, was "born of a long ancestral line which had handed on the art of bone-setting from father to son".

There is another tradition arising from treatment by movement—namely, physical education. This we owe largely to the Swedish School, and in particular to Peter Ling. Ling received his training in the army and therefore developed his principles on the traditions he found there. In some forms physical education was also well established in the Greek and Roman civilizations. It is not yet always realized how much we owe to this branch of our subject.

Of recent years the word "rehabilitation" has been introduced into physical medicine as if it were something entirely new. The idea of course embodies age-old principles fundamental to all medical and surgical treatment. Recent developments in physical medicine have, however, revealed possibilities not realized before. Rehabilitation as we now know it marks, therefore, a perfectly natural development which was inevitable as the value of physical methods became more fully recognized. It is very unlikely that full development has been reached. Even as it is, it is surely indicative of another triumph for treatment by movement.

Physical medicine embraces many other forms of treatment than those of rest and movement: these include treatment by electrical methods, which are ever increasing, and also treatment by rays outside the visible spectrum as well as those in it. The time when electrical treatment was practically unused is within the recollection of a few of us; therefore its development has been too rapid for it to have established a separate tradition. It is the rather mushroom-like growth of a science based on a short history. All we can say at present is that electrical forms of treatment will be found of value in so far as they assist natural physiological processes.

The one thing that must always be kept in mind is that throughout Nature there exists the tendency to repair, which is a tremendous asset for all those engaged in the treatment of the human body. So strong is this tendency that (however humiliating may be the confession) now and again a patient will recover in spite of, and not because of, our treatment. It is one thing to pronounce a patient cured, but quite another to say what cured him. Also, we have to remember the full implication of the question: "Wilt thou be made whole?"; for if the answer is in the negative, it is certain that all methods of physical treatment will fail. It is often necessary

to inspire this will to get well and to remember the words, "Go thy way; thy faith hath made thee whole."

After all, did not Ambroise Paré impress on his students: "I set his fracture; God healed it"? It is well to remember too that not even an orthopaedic surgeon has yet created an osteoblastic cell, though on his skill will depend whether the cell performs its function to useful purpose. The guiding principles, therefore, of all physical medicine must be based upon Nature and an understanding of its natural processes. All we can hope to do is to render cure possible when, without our help, it would not be so; to apply such treatment as we know will hasten repair; and—perhaps most important—to avoid the prescription of treatment which will retard it. Rest is an essential part of the existence of all living things: it is as necessary a part of the prescription of physical medicine as of any other form of treatment, and often more so.

Movement and Rest, Rest and Movement; in these are found the essence of Life and the true tradition of Physical Medicine.

BRITISH ASSOCIATION OF PHYSICAL MEDICINE

ANNUAL MEETING, 1953

Preliminary Announcement

The Annual Meeting of the Association will be held at University College Hospital, Gower Street, London, W.C.1, on Friday and Saturday, April 17 and 18, 1953. The provisional arrangements are as follows:

Friday, April 17

10.30 a.m.	Coffee.
11 a.m.	Discussion on "Training for Physical Medicine".
1 p.m.	Lunch.
2.30 p.m.	Clinical Meeting.
4.30 p.m.	Tea.
7.15 for 7.45 p.m.	Annual Dinner at the Royal College of Surgeons.

Saturday, April 18.

10 a.m.	Annual General Meeting.
10.30 a.m.	Coffee.
11 a.m.	Films.
1 p.m.	Lunch.
2.30 p.m.	Short Papers.
4.30 p.m.	Tea.

A CRITICAL EVALUATION OF TREATMENT OF TRAUMATIC EFFUSIONS OF THE KNEE

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AN effusion into the knee-joint frequently follows arthrotomy. As a rule, with proper post-operative care the effusion subsides in a few days, but in a high proportion of cases it recurs when active flexion of the knee is started. An effusion is Nature's method of protecting a joint, but so long as it is present full functional rehabilitation cannot be undertaken. If the effusion persists longer than a few weeks, the articular ligaments become permanently stretched, gross wasting of the quadriceps muscle occurs, and full movements of the joint may never be regained.

In this paper is described a clinical investigation to determine the best method of accelerating the disappearance of a knee effusion.

Material

The investigation was carried out at the R.A.F. Medical Rehabilitation Units at Chessington, Collaton Cross, and Headley Court. There were 260 patients in the series. In 247 (91%) of these the effusion followed meniscectomy, and 13 (9%) had a simple non-operative traumatic effusion independent of any pathology in the knee-joint. Cases in which the effusion was associated with a definite pathological condition, such as torn cartilage, loose bodies, osteo-arthritis, chondromalacia patellae, or specific arthritis, were excluded. Of the meniscectomies 39·2% were right medial, 32·5% left medial, 13·5% left lateral, 12·2% right lateral, 1·3% left medial and lateral combined, and 1·3% right medial and lateral combined.

Procedure

On the patient's arrival at the rehabilitation unit a full clinical examination was made and the size of the effusion noted, the following grades being recognized: 0, no effusion; 1, a just perceptible trace of fluid; 2, clearly visible effusion; 3, moderate effusion; and 4, gross effusion. Only cases in Grades 3 and 4 at the beginning of treatment were included in this series, and treatment was continued until the effusion had disappeared completely. Assessment of the amount of effusion was at first attempted by measuring the maximum circumference of the knee with a tape measure, but as the shape of the knee and the site of maximum circumference varied greatly from one patient to another, this method was considered too inaccurate and therefore was discarded. Also it was noticed that a visible effusion might be present without there being any increase in the knee circumference.

All patients were then assigned to the "quadriceps" class, where non-weight-bearing static exercises were carried out, flexion of the knee being prohibited. When the effusion had subsided completely and the quadriceps had recovered enough strength for weight-bearing, patients moved up to the "early knees" class. Here active flexion and extension exercises with partial weight-bearing were started. Finally, if patients after their period in the "early knees" class were still unfit for the full duties of their trade, they joined the "late" class, where a programme of strenuous exercises aimed at restoring full function and confidence was carried out. All three classes—"quadriceps", "early", and "late"—followed a daily routine consisting of three hours' specific remedial exercises and three hours of organized remedial games selected to suit the disability.

The average time in hospital was 26·2 days, and at the rehabilitation unit 32 days. All the patients were males, the average age being 23 years.

Patients were divided into six groups. All groups carried out active rehabilitation in the "quadriceps" class, and, in addition, Group 1 had the knee supported with a crêpe bandage; Group 2 were given daily applications of constant-current galvanism; Group 3 wore a back splint and bandage; Group 4 had a back splint and bandage together with daily anodal galvanism; and Group 5 were treated with rest in bed as well as a back splint and bandage. Patients in Group 6 had no additional treatment. All patients were examined a week after the initial examination and thereafter twice weekly.

The "back splint" referred to above consisted of a light metal splint extending from mid-calf to mid-thigh and applied behind the knee (see Plate I, A).

Technique

Group 1

In this group a crêpe bandage was worn extending from mid-calf to mid-thigh; it was applied firmly but allowed the patient to walk in comfort. The bandage was first applied by the medical officer, and the patient was taught the correct manner of application so that he could apply the bandage himself. It was removed for the remedial exercises but worn during the games periods and at all other times, day and night.

Group 2

These patients received a daily period of "through and through" constant-current galvanism in the place of one games period. All patients in this group performed their remedial exercises in the class, but wore no supporting bandage. The procedure was as follows:

The patient sat on a treatment couch and the skin over the knee-joint was cleansed. The scar area in meniscectomy cases was covered with vaseline. Two pieces of lint folded into pads of 16 thicknesses and measuring one-quarter the circumference of the knee (average 4×4 inches) were soaked in 1% saline solution and applied, one

anteriorly and the other posteriorly, to the knee-joint. A metal electrode half an inch smaller in diameter than the lint pads was placed on top of each pad. The anterior electrode was connected to the anode terminal of the source of constant current, and the posterior electrode to the cathode terminal. The pads and electrodes were then covered with jaconet and firmly bandaged in position with a crêpe bandage. The patient was told what sensation to expect, and the current was then increased. At first each treatment lasted 15 to 20 minutes; the time was then gradually extended until the patient was receiving 30 minutes' treatment. The average strength of current used in the early treatments was 14 milliampères, and this was increased successively with each treatment until the patient was receiving up to 2 milliampères per square inch of pad, according to his tolerance. The average strength of current used in the later treatments was 32 milliampères. On each occasion the amperage, time of treatment, and skin condition following treatment were noted.

Group 3

The patients in this group wore a back splint and bandage. With the knee in full extension, a crêpe bandage was firmly applied to the leg from mid-calf to mid-thigh. A back splint was then applied and bandaged securely in position (Plate I, B). This splint was worn day and night; exercises were carried out and games played with the splint on, and it was removed only to enable the medical officer to observe the effusion. No attempt at flexion was made until the effusion had subsided completely. All patients found that they could walk in comfort while wearing the splint, and did not require sticks.

Group 4

The patients in this group wore a back splint and bandage as described above. Instead of one games period they received a daily period of anodal galvanism, as follows:

The patient was seated on a couch and the skin cleansed. Vaseline was applied to the scar in post-meniscectomy cases. A lint pad (16 thicknesses) was applied which completely encircled the knee-joint and extended in width over the area of the effusion. A similar, but slightly larger, pad was placed on the lumbar region. Both pads were soaked in 1% saline solution. A metal electrode half an inch smaller than the pads was placed over each pad. The electrode on the knee was connected to the anode terminal of the source of constant current, and that in the lumbar region was connected to the cathode terminal. The pads were covered with jaconet and held in position by bandages. The patient was told what sensation to expect and the current then slowly increased. At first each treatment lasted 30 minutes, and the duration was progressively increased until the patient was receiving treatment for one-hour periods. The average strength of current used was 10 milliampères. On each occasion the amperage, time of treatment, and skin condition following treatment were noted.

Group 5

Patients in this group were strictly confined to bed with the knee bandaged and in a back splint until the effusion had completely subsided. Supervised quadriceps exercises were performed for ten minutes of every hour of the day with the back splint in place.

Group 6

These patients received full-time treatment in the "quadriceps" class, in common with all cases in the series; otherwise their activity was not restricted in any way.

Results

Three main experiments were carried out, and for each experiment patients completely immobilized in a back splint served as a control.

First Experiment

The object of this experiment was to compare the effect of (*a*) daily anodal galvanism and back splint, (*b*) rest in bed and back splint, and (*c*) back splint alone, on the time taken for the effusions to disappear.

(*a*) 50 patients were treated with back splint and pressure bandage and in addition received a daily period of anodal galvanism. In 4 cases there was a traumatic, non-operative effusion, and in the rest the effusion followed meniscectomy. The average time for complete disappearance of the effusion was 14·2 days.

(*b*) 19 cases were treated with complete rest in bed and immobilization in a back splint. All were post-meniscectomy cases. The average time taken for the effusion to disappear completely was 9·4 days.

(*c*) 45 patients were treated with back splint and pressure bandage alone. Meniscectomy had been performed on all these patients. The average time taken by the effusion to disappear was 9·9 days.

Second Experiment

This experiment was aimed at comparing the time taken for the effusion to disappear (*a*) with and (*b*) without a back splint.

(*a*) 45 patients (all post-meniscectomy) were treated with a back splint and pressure bandage; the average time required for the effusion to disappear was 9·9 days.

(*b*) 41 patients were treated in the "quadriceps" class without any other form of treatment. Of the cases 5 had a traumatic, non-operative effusion; the other 36 had a post-meniscectomy effusion. The average time for complete disappearance of the effusion was 23·3 days.

Third Experiment

This experiment was carried out to compare the effect of (*a*) wearing a crêpe bandage, (*b*) wearing a back splint and pressure bandage, and (*c*) treatment with "through and through" galvanism, on the time taken for the effusion to disappear.

(*a*) 19 patients were treated in the "quadriceps" class and wore a supporting crêpe bandage; 2 of these had a traumatic, non-operative effusion, and the other 17 had a post-meniscectomy effusion. The average time taken for the effusion to disappear was 23 days.

(*b*) 25 patients were treated with a back splint and pressure bandage.

Of these, 2 had a traumatic, non-operative effusion and in the other 23 the effusion followed meniscectomy. The average time taken for the effusion to disappear was 11·6 days.

(*c*) 16 patients were treated in the "quadriceps" class and received a daily period of "through and through" galvanism. All were post-meniscectomy cases. The average time for disappearance of the effusion was 24·8 days.

Result of Treatment in Back Splint alone

In all, 115 cases were treated in a back splint and bandage, the average time taken for the effusion to disappear being 10·3 days.

Discussion

It will be seen from the results that support with a crêpe bandage did not accelerate the disappearance of an effusion. With no other treatment than static quadriceps exercises, the average time needed for the effusion to disappear was 23·3 days; when a crêpe bandage was worn the average time was 23 days. This period of 23 days was, in fact, the natural "life" of an effusion in this series, and it is interesting to note that an effusion will subside without treatment provided the quadriceps muscle is continually exercised and the patient takes care to bend his knee as little as possible.

It is common belief that support with a crêpe bandage will accelerate the disappearance of an effusion. Many patients, particularly those who regularly play soccer, specifically ask for such a bandage when an effusion appears, and for some months after meniscectomy a high proportion wear one when playing football.

So far as we are aware there is no report in the literature wherein the rates of disappearance of an effusion with and without the application of a crêpe bandage are compared. The idea seems to have gained support from the wide and successful practice of strapping strains and sprains associated with local oedema. However, our results seem to show that the mechanism of disappearance of joint effusions is not the same as the mechanism of local tissue oedema.

The wearing of a crêpe bandage has two main disadvantages: it allows a certain degree of knee flexion, which tends to keep the effusion going; and it prohibits full extension of the knee, thus leading to wasting of the quadriceps. Even though the bandage is applied with the knee in full extension, the patient with walking soon wears the bandage loose and tends to hold the knee in 5 to 10 degrees of flexion. Furthermore, the patient feels that the bandage is giving adequate support and "strength" to the knee. This militates against the fundamental prerequisite of the rehabilitation of all patients with knee injuries, which is to make the patient "quadriceps conscious". Conversely, if the bandage is worn too

tight, the absorption of the effusion is slowed down and oedema of the lower leg may occur.

Daily treatment with "through and through" galvanism also did not accelerate the disappearance of the effusion, the average time required for the effusion to disappear in such cases being 24·8 days.

In this series, continuous immobilization of the knee in a bandage and back splint proved to be the most efficient and reliable method of dispersing a knee effusion. Comparison of the results of treating the patient in bed with those of treatment without rest in bed shows very little difference. The average time taken for the effusion to disappear with rest in bed and a back splint was 9·4 days, and without rest in bed 10·3 days. These results suggest, first, that complete immobilization of the knee is the method of choice in the treatment of traumatic knee effusions, and, secondly, that it is not necessary to put to bed a patient with a traumatic knee effusion. It is, however, essential that the patient assiduously exercises his quadriceps muscle throughout the period of treatment. Although an effusion can subside with immobilization in the presence of weak quadriceps muscles, it is our experience that as soon as active rehabilitation is started the effusion will immediately recur unless the quadriceps muscle is strong enough to take the weight of the body on the bent knee. One of us (Millard, 1953) has shown that electrical stimulation of the quadriceps does not accelerate the disappearance of an effusion, but that active exercise is to be preferred.

We did not find that anodal galvanism combined with immobilization in a back splint had any effect in accelerating the disappearance of a knee effusion. Indeed, the effusion took longer to disappear with galvanism (14·2 days) than without (10·3 days). There are two possible explanations of this—first, some slight flexion of the knee is unavoidable at the beginning and end of treatment (i.e. when the back splint and bandages are respectively removed and replaced); secondly, the galvanism may actually irritate the joint and keep the effusion going, rather than disperse it. In the patients treated with galvanism, 8 (11%) had such a severe erythematous reaction that treatment had to be discontinued (these cases are not included in the series reported).

Techniques of administering constant current vary considerably. We chose the two techniques—"through and through" galvanism and anodal galvanism—which are most frequently described in the textbooks (Kovacs, 1949; Turrell, 1929; Morris, 1941) and were most familiar to our physiotherapists, who had all been trained at different schools. Throughout the experiment meticulous attention was given to the details of technique, as this is stressed by the advocates of galvanism as being of great importance.

We conclude from our experiments that constant-current galvanism has no place in the treatment of knee effusions and that the method of choice is immobilization of the knee in a back splint and bandage, with

intensive quadriceps exercises. In fact we feel justified in concluding from our results that absolute immobilization of the knee is of paramount importance.

Summary

1. An investigation has been carried out in 260 patients with traumatic effusions of the knee to discover the treatment of choice in accelerating the disappearance of an effusion. In 95% of cases the effusion followed meniscectomy, and in 5% was a simple non-operative traumatic effusion.

2. All patients were given remedial quadriceps exercises at an R.A.F. Medical Rehabilitation Unit; in addition five different treatments were investigated: (*a*) support with a crêpe bandage; (*b*) constant-current galvanism; (*c*) immobilization in a back splint; (*d*) application of a back splint and anodal galvanism; and (*e*) rest in bed with immobilization in a back splint.

3. The average time required for the disappearance of the effusion was 23·3 days with exercises alone, 23 days with a crêpe bandage, 24·8 days with constant-current galvanism, 10·3 days with immobilization in a back splint alone, 14·2 days with back splint and anodal galvanism, and 9·4 days with rest in bed and immobilization in a back splint.

4. It is concluded that the use of crêpe bandages alone or of galvanism (either "through and through" technique or anodal galvanism) has no place in the treatment of knee effusions.

5. The method of choice was found to be complete and continuous immobilization of the knee in a back splint and bandage with intensive static quadriceps exercises.

6. The results further suggest that rest in bed is not necessary to accelerate the disappearance of a knee effusion.

Acknowledgments

It is a pleasure to acknowledge the invaluable help we have received from our physiotherapists, and in particular Mrs. L. Baker. We should like to thank Wing Commander Keir for his advice and encouragement, and all the patients for their co-operation.

Our thanks are due to Squadron Leader P. J. R. Nicholls, who carried out part of the work at the R.A.F. Medical Rehabilitation Unit, Headley Court, and to Squadron Leader E. Stroud, who was in charge of the group of patients treated with rest in bed at the R.A.F. Medical Rehabilitation Unit, Collaton Cross.

Lastly we wish to thank the Director-General of Medical Services, Royal Air Force, for permission to publish this paper.

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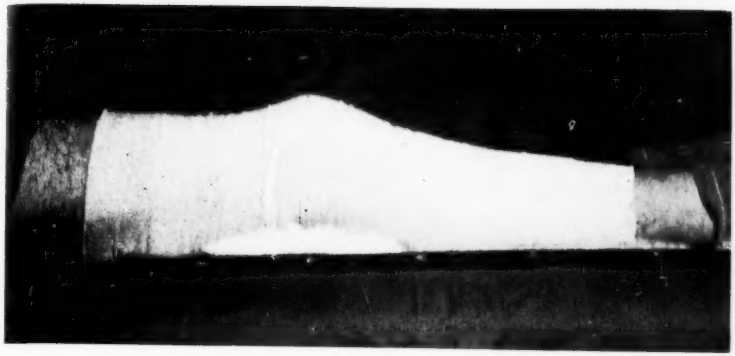
PLATE I



A, Showing the back splint and bandage in position.

B, The knee has been supported by a crêpe bandage extending from mid-thigh to mid-calf and then the back splint applied and firmly bandaged in position.

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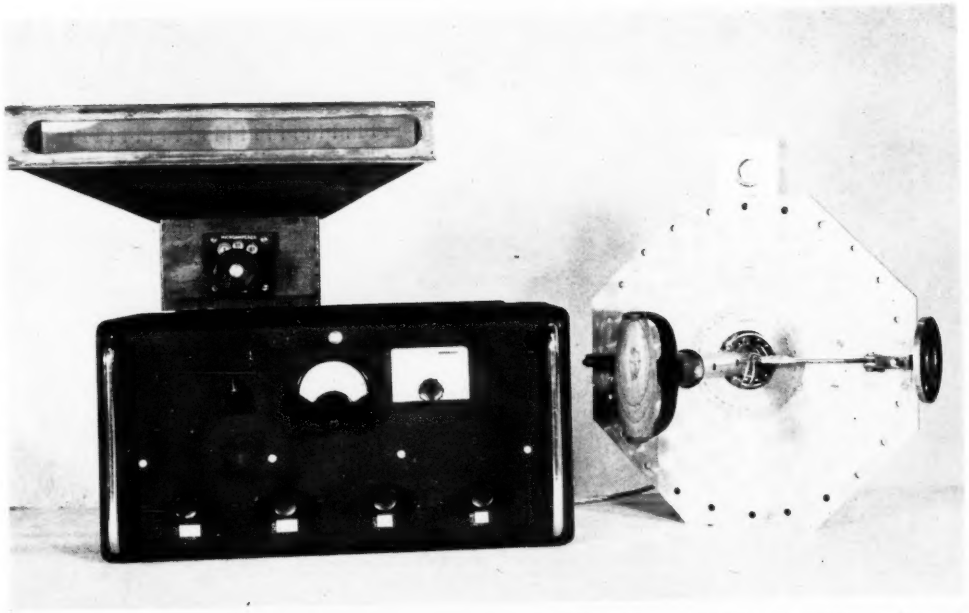
PLATE II



The strain-gauge dynamometer in its three component parts. The "double" spring-steel bar apparatus shown is the one that has been used for measurement of the strength of muscle groups in the upper limb. The hand grip attached to the spindle was one of the methods used for the recording of the strength of pronation and supination of the hand.

A STRAIN-GAUGE DYNAMOMETER FOR MEASURING THE STRENGTH OF MUSCLE CONTRACTION AND FOR RE-EDUCATING MUSCLES

By H. D. DARCUS

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THIS work, which was started about four years ago, was stimulated by the apparent meagreness of the information available on the maximum voluntary muscle strength of normal subjects and the factors affecting it. Such data as did exist were confined mainly to flexion of the elbow and extension of the knee. Recently, however, more attention has been paid to this aspect of muscular activity, particularly in America (Clarke and Bailey, 1950; Clarke *et al.*, 1950; Wakim *et al.*, 1950; Elkins, Leden, and Wakim, 1951).

The usual clinical methods of estimating the performance of a muscle against gravity or against manual resistance may provide results of considerable value in the hands of trained observers, but for accurate comparisons a more objective method is needed. In spite of the fact that this need has been appreciated for many years, there is still no generally accepted objective method of measuring muscle strength, although many attempts have been made to devise one. In order to meet the requirement for an accurate method which may also be of general application, a strain-gauge dynamometer has been constructed, and although a strain-gauge technique has been previously used for recording muscle strength (Ralston *et al.*, 1947; Tuttle, Janney, and Thompson, 1950; and Wakim *et al.*, 1950) the method of application here used is original.

The principle of the apparatus is that the muscle force exerted during a maximum voluntary contraction is resisted by a spring-steel bar, the latter bending in proportion to the torque applied. The degree of this deformation is measured by the change in the electrical resistance of two strain-gauge elements fixed to the bar.

Design of the Apparatus (Plate II)

The dynamometer consists of a tubular metal spindle which passes perpendicularly through a ball-race bearing in the centre of a rigid metal plate. A spring-steel bar traverses the spindle immediately in front of the plate. The ends of the bar can be fixed by metal pegs at angular positions of 15° intervals. The spindle is provided with a pointer which indicates the angular position of the bar on a scale attached to the metal plate.

The subject is positioned so that the spindle of the apparatus coincides with the axis of the movement to be tested. Various attachments to the

spindle have been devised to fix that part of the limb being acted upon by the muscular contraction. In general, this takes the form of a rigid bar on which the limb can rest and be fastened by adjustable rubber-lined metal cuffs or leather straps. The torque exerted about the spindle causes a deformation of the spring-steel bar. By altering the angular position of the spindle and the support, the torques developed in different positions of the joint can be determined. The fact that the axis of the spindle corresponds with that of the movement produced by the muscle group being tested allows different joint positions to be taken up with the minimum of interference to the general posture of the subject.

Assuming that the torque exerted is constant, the degree of deformation of the bar depends on its dimensions. To render the contractions virtually isometric, the dimensions of the bar should be such that with the maximum anticipated torques there is only a limited degree of angular movement of the spindle. This also ensures that the strain gauges affixed are not unduly stretched or compressed.

The strain-gauge elements each consist of a thin card wound with fine resistance wire. When the card is stretched in a direction along the axis of the wire, each turn of the wire is also stretched and its resistance increases. The resistance of the whole element, therefore, changes by an amount equal to the sum of the changes in resistance of the individual turns. Similarly, its resistance decreases if the card is compressed. The elements are firmly fixed to the upper surface of the bar, one on either side of the spindle (Fig. 1). The gauges, protected by a coating of waterproof material,

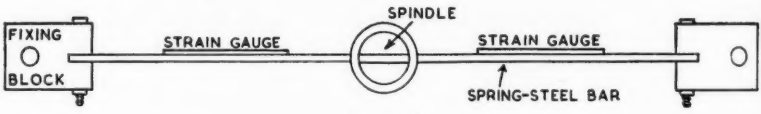

FIG. 1 (*a*).

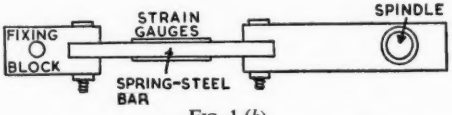

FIG. 1 (*b*).

Diagrams of the general design of (*a*) the "double" bar and (*b*) the "single" bar apparatus with the position of the strain gauges.

are connected in a Wheatstone-bridge circuit (Fig. 2). Both coarse and fine adjustment of the bridge balance can be made by the apex resistors. This adjustment is necessary to eliminate any small differences in the resistance of the strain gauges when unstressed and to counterbalance the effect of the torque exerted by the weight of the limb support and of the limb being

examined. The use of two strain gauges, besides compensating for changes in ambient temperature, doubles the sensitivity of the apparatus, as the deforming force causes one to be stretched and the other to be compressed.

The bridge is connected to a 40-volt D.C. supply. Between the supply and the bridge are two variable resistors which allow a fine and coarse adjustment of the voltage between 0 and 40. The output of the bridge is taken to a galvanometer and the deflection of the light spot is read off from a 26-cm. ground-glass scale which is 40 cm. from the reflecting mirror.

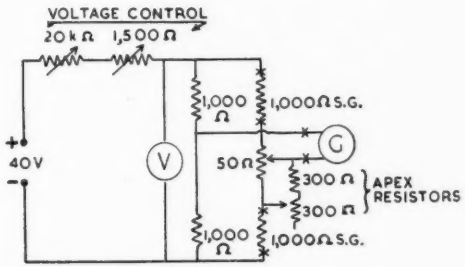

FIG. 2.

Diagram of the Wheatstone-bridge circuit used to measure the change in the resistance of the strain gauges (SG) when under stress. V represents the voltmeter and G the galvanometer.

There are three ranges of sensitivity of the galvanometer being used: 5, 25, and 125 microamperes for full-scale deflection. This method of display is simple and has the added advantage that it can readily be seen by the subject, although it does not automatically provide a permanent record. In order to obtain such a record, the output, which may be less than 1 microampere, can be amplified to drive a pen recorder.

To determine the galvanometer reading with known torques, a metal pulley from which weights can be suspended is fixed to the spindle at the back of the metal supporting plate. This calibration is carried out at the beginning of each session to determine the torque per centimetre deflection of the light spot, and at the end to detect any faults that may have occurred. The linearity of the galvanometer is checked by applying known currents to it; a circuit to provide for this is included.

The apparatus described has been used mainly for investigations on the upper limb. For extension and flexion of the knee certain modifications were made, although basically the apparatus was the same. The main differences were that the spring-steel bar was shorter and thicker and that it extended only to one side of the spindle, the strain gauges being fixed to the upper and lower surfaces of this bar (Fig. 1). This method is being used in a "universal" instrument that is under construction.

Linearity of the Apparatus

At all ranges of galvanometer sensitivity the recordings, for practical purposes, are linear both when the voltage is increased with a fixed torque and when the torque is increased at a fixed voltage. There is slight departure from linearity amounting to about $+1 \cdot 5\%$ inherent in the galvanometer, since the scale is flat instead of curved. This could be corrected by incorporating a scale appropriately curved, but this is not considered necessary, especially when the variation of the torques applied to the apparatus is so much larger.

Range of Sensitivity of the Apparatus

With the upper-limb apparatus with the "double" bar, a torque of 0·02 kg.-m. produces a deflection of 1 cm. when the galvanometer is on the 5 microamperes for full-scale deflection range and 40 volts is applied to the bridge. Accepting an arbitrary limit of 2° spindle rotation, which renders the contraction virtually isometric, the maximum torque that can be recorded is 3·6 kg.-m. In the "single" bar apparatus, under the same conditions, a torque of 0·15 kg.-m. gives a deflection of 1 cm. and the maximum torque that can be recorded is 40 kg.-m. Thus, taking a reading of 1 mm. as the smallest that can be read on the scale, the ratio between the smallest and the largest torque that can be recorded is about 1 : 1,600 with the "double" bar apparatus and about 1 : 2,400 with the "single" bar type. Torques of much greater magnitudes have been accurately recorded with both types of apparatus. This obviously resulted in a larger degree of spindle rotation than the arbitrary limit of 2°, but it can be shown that more than four times this rotation can occur before the deformation of the bar overstrains the gauges.

Methods of Varying the Sensitivity

The sensitivity of the apparatus depends on the current in the galvanometer, and the sensitivity of the galvanometer on this current and on the dimensions of the spring-steel bar.

The current flowing through the galvanometer (I*g*) may be determined from the following equation:

$$Ig = \frac{E}{2R} \cdot \frac{x}{R} \cdot \frac{R}{G+R}$$

where E is the voltage applied to the bridge, R the resistance of each of the arms of the bridge, G the galvanometer resistance, and x the change in resistance of the strain gauges when compressed or stretched (Fig. 3).

Thus the galvanometer current depends on the current in the strain gauges $\left(\frac{E}{2R}\right)$, the relative change in resistance of the strain gauges $\left(\frac{x}{R}\right)$, and the galvanometer resistance for a given series of bridge resistances.

The current in the strain gauges should be limited to below 20 micro-amperes. Therefore, if 1,000-ohm strain gauges are being used, the maximum voltage applied to the bridge is 40 volts.

The strain gauges are suitable for measuring strains of 0·5% to a few parts in a million. As the gauge factor (i.e. the ratio of the percentage increase in resistance to the percentage increase in strain or length) is 2, the maximum relative change in the resistance of the strain gauges $\left(\frac{x}{R}\right)$ is 1%. This can be doubled by replacing the resistances forming the other two arms of the bridge with strain gauges and mounting these with other strain

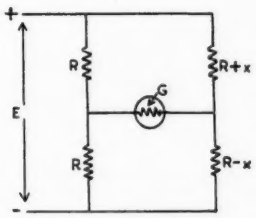

FIG. 3.

Schematic diagram of the basic Wheatstone-bridge circuit to indicate the electrical variables of the strain-gauge dynamometer. R represents the resistance of the fixed bridge resistances and the resistances of the unstressed strain gauges, x the change in resistance of the strain gauges when stressed, and G the resistance of the galvanometer.

gauges on the spring-steel bar. A disadvantage of this arrangement is the increase in the number of connecting wires required.

From the above formula it can be seen that increasing the galvanometer resistance (G) decreases the current in the galvanometer. However, the increase in the sensitivity of the galvanometer with larger resistances more than balances the reduction in current. It is suggested that in order to obtain as large a range of sensitivity as possible, a galvanometer with a universal shunt, giving a series of sensitivity ranges, should be used.

Increased sensitivity can also be obtained by increasing the length of the light beam. This will be limited by the size of the galvanometer that is convenient for use with the apparatus rather than by optical factors.

Various ranges of sensitivity can also be effected by having interchangeable spring-steel bars. However, this is probably unnecessary since, for a given range of torques anticipated in any of the muscle groups that it is wished to examine, a bar could be found which would not bend too much for the maximum torques, the necessary increase in sensitivity for smaller torques being achieved by other methods.

The relationship between the torque exerted, the dimensions of a single

bar, and the degree of angular movement of the spindle can be calculated approximately from the following formula:

$$T = \frac{90\ \theta\ b\ t^3\ (l\ +\ a)^2}{l^3}$$

where T is the torque in kilogramme-metres, b the breadth of the bar, t the thickness and l the length in centimetres, a the radius of the spindle in centimetres, and θ the angular movement of the spindle in degrees (Fig. 4).

FIG. 4.
Schematic diagram of the effect of the angular movement of the spindle on the spring-steel bar. l represents the length of that part of the bar free to bend, a the radius of the spindle, and θ the angular movement of the spindle.

Fixation of Limb (Fig. 5)

One of the main problems encountered with the apparatus is the fixation of the limb. The fixation must not limit in any way the application of the maximum voluntary contraction, and at the same time it must preserve the relationship of the part of the limb above and below the joint around which the torque is being developed, and maintain the correspondence between the axis of the spindle and the axis of the attempted movement of the muscle group being studied.

The peripheral part of the limb has to be fixed to the limb support. Usually two rubber-lined metal cuffs are used: one just below the joint on which the muscle group being tested is acting, and the other at a more distal level. In certain instances the proximal cuff may, for convenience, be replaced by a leather strap. It is essential that these cuffs should fit accurately, otherwise they may limit the effort by causing discomfort or even pain. In order to distribute the pressure more evenly, it is proposed to fix the limb by plastic casts. For clinical purposes in the upper-limb measurements, some, if not all, of the force can be exerted through the hand, as has been done in measurements of pronation and supination and of shoulder abduction and adduction. The cuffs are useful, however, in maintaining the position of the limb during the development of a contraction and in cases, complicated by weakness of the hand, when there is no effective grip.

In measurement of muscle force in the upper limb, it is generally sufficient to allow the weight of the trunk to fix the proximal part of the limb. It soon becomes apparent to the subject that muscular exertions other than those required make little or no difference to the torque exerted. The subject is seated, so that he can stabilize his body by counterpressure

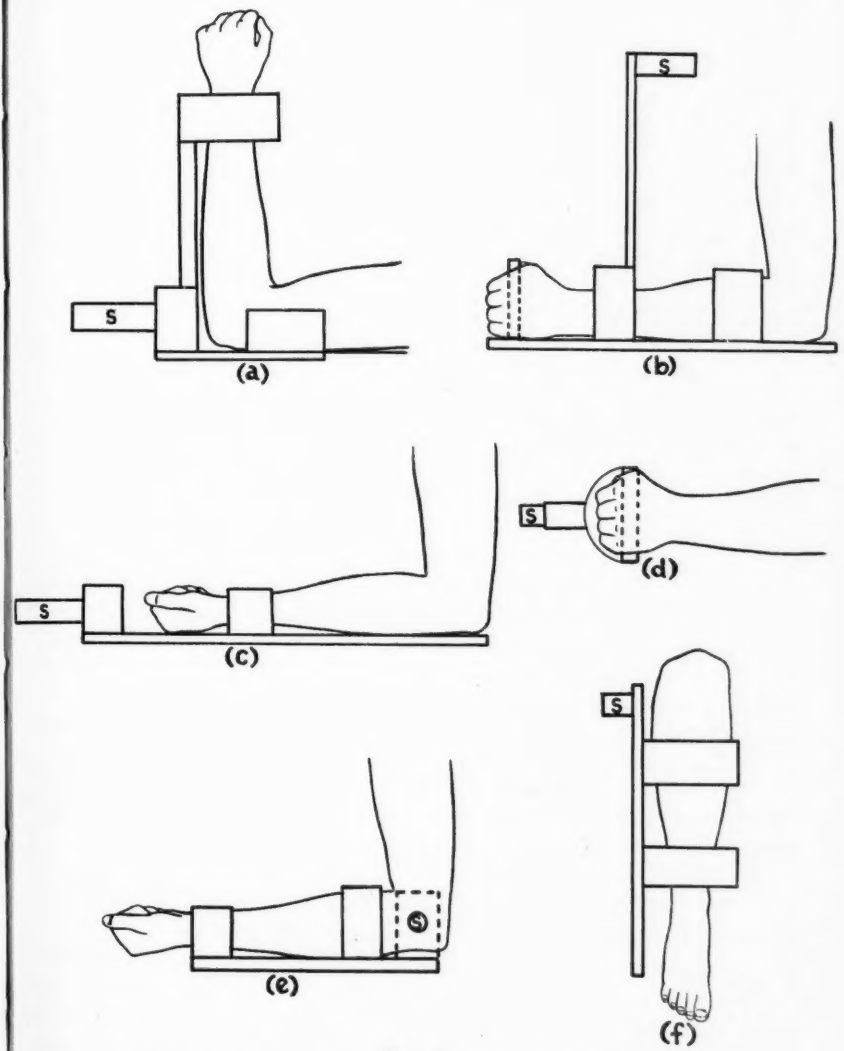

FIG. 5.

Diagrams to illustrate the methods that have been adopted to fix the limb in the measurement and training of isometric contraction of different muscle groups. S represents the spindle, the axis of which corresponds with the axis of the attempted movement. *a*, Medial and lateral rotation of shoulder. *b*, Abduction and adduction of shoulder. *c*, Pronation and supination with cuff. *d*, Pronation and supination with hand grip. *e*, Flexion and extension of elbow. *f*, Flexion and extension of knee.

between a back-rest and a suitably sloped foot-rest (Darcus and Weddell, 1948).

The measurements in the lower limb presented a more difficult problem. For instance, in extension of the knee with the leg fixed to the apparatus, the torque exerted is sufficient to lift the body of a normal subject. At first it was thought that it would be necessary to have the thigh or pelvis rigidly fixed, but it was found satisfactory to have the subject lying on a bed with no restriction above the knee. When an attempt is made to extend the knee, there is some movement at the knee due to raising of the thigh and arching of the back. This leads to no side-effects, and it has been determined that the only torque being recorded is that of knee extension.

Fixation of Apparatus

The present apparatus for upper-limb measurement is attached to a steel column mounted on a heavy platform. For knee extension and flexion the apparatus is attached to the bed on which the subject is lying. For clinical purposes, it is proposed to make both upper and lower limb measurements with the apparatus fixed to an iron bed.

Method of Use

The following method has been adopted in investigations using the apparatus. The galvanometer spot is centred when no current is being applied to the bridge. The voltage supply to the bridge is then switched on and left for at least half an hour. At the end of this period the bridge is balanced and the apparatus calibrated. The limb is then placed in the support. If it is not held in the vertical plane, it will produce a deflection even while relaxed, owing to the pull of gravity. This deflection is balanced out.

A preliminary run is made to determine the torques to be expected, and the calibration is set so that expected variations in torque will not cause deflections off the scale.

Measurement of Strength of Isometric Contraction

As there are quite wide variations in the maximum torques exerted by the same subject in successive contractions during the same session and also on successive sessions under the same conditions, ten measurements are taken at intervals of one minute on one or more days in order to obtain a fair estimate of the strength of the muscle group being studied. On each occasion the subject is allowed five seconds in which to develop the contraction. This was adopted, on one hand, to prevent a too sudden effort resulting in a "snatch" and, on the other hand, to prevent a prolonged effort at the end of which the subject merely maintains rather than increases the strength of his contraction. In general, the major effect is produced during the first two or three seconds.

Muscle Training

For the training of muscles the following procedure is used. The subject is required to make thirty maximum exertions at intervals of one minute, preferably repeating this on successive days. This training procedure has been decided from experience with normal subjects and in clinical cases; the one-minute interval usually prevents a falling off in performance during the half-hour period, half an hour being about the maximum time that exertion can be maintained without causing after-effects such as muscle stiffness or soreness. If this should occur, it may reduce the performance in a subsequent training period. Whether or not this training procedure is the optimum has not been specifically investigated, and it is possible that it should be varied with the muscle group being trained and the nature of the patient's condition. The half-hour period, incidentally, corresponds quite well to that recommended by De Lorme and Watkins (1951). It was anticipated that this method of training would rapidly bore the patient, but we have not had any evidence of this even when training has extended over several months.

Experimental Observations

The apparatus has been used to measure the isometric muscle contraction in different joint positions of the various muscle groups acting in the following movements: pronation and supination of hand (Darcus, 1951; Salter and Darcus, 1952); flexion and extension of elbow; abduction, adduction, and medial and lateral rotation of shoulder; flexion and extension of knee; and plantar flexion of foot.

A study with normal subjects has also been made of the effects of repeated isometric exertion on the strength of the muscle group trained and on other muscle groups of the same limb and of the opposite limb. The accompanying table gives a summary of the results of some of the training experiments on normal and clinical subjects. The overall increase in force has been determined by calculating the percentage difference (A) between ten readings taken before the experiment and the first ten readings on the last day, and (B) from the regression line derived from all the readings. Lastly, a comparison has been made of isometric training and isotonic training involving the lifting of heavy weights (see page 174).

The general results of these experiments indicate that both isometric and isotonic training improve muscle strength; but, whereas the improvement is apparent from the first day in isotonic training, several training periods (about six) are necessary before any definite improvement is seen with isometric training. In both instances the main improvement occurs during the first thirty daily training periods. Isometric or isotonic training improves the isotonic or isometric performance and, although in the isometric training experiments the muscles were exercised in only one position of the joint, improvement was found in all other positions. The strength of

muscle groups not directly exercised, both of the same and of the other limb, was also increased. During the course of all these experiments the subjects had no knowledge of their results, although they could estimate their improvement during isotonic training by the increased distance they were able to move the weight.

The apparatus is also being applied to the investigation and treatment of a number of clinical cases receiving no other form of treatment (see Table). In two cases of poliomyelitis with marked bilateral weakness of the knee extensors the muscles have been trained for the thirty-minute period on three days a week. In both cases there has been marked improvement which has been paralleled by the general clinical progress. In one of these patients the quadriceps femoris on each side was assessed manually as producing only a flicker of contraction. Training has been carried out in two cases of weakness of abduction of the shoulder mainly due to weakness of the deltoid muscle. One case followed an operation for recurrent dislocation of the shoulder-joint, and the other a brachial plexus lesion. In both cases, again, the increase in muscle strength was marked. During the course of the training the patients were allowed to see the deflection of the galvanometer spot produced by their efforts, thus providing an incentive to maximum effort on each occasion.

Full details of these experiments will be published elsewhere.

Clinical Application of Apparatus

It is appreciated that the improvement recorded in the clinical cases may not be entirely due to the method of training, but it is believed that the results warrant more extensive trials.

The apparatus can be used to obtain an objective measure of muscle strength in the evaluation of the degree of disability following disease or trauma. The determination of this strength at regular intervals would provide a guide in assessing the effects of various forms of treatment. As the measurements are not dependent on the subjective impressions of the observer and the technique can be readily standardized, they can be taken by different individuals on different occasions.

The same apparatus can also be used as a means of providing heavy resistance exercise, the value of which has been stressed by De Lorme and Watkins (1951). Since a very wide range of sensitivity is allowed and the resistance depends on the activity of the subject, there is no need for alteration of the resistance as the patient improves. This appears to be one of the disadvantages if springs or weights provide the resistance against which the patient has to work. The method also eliminates a possible danger in apparatus requiring the moving of weights, and reduces the risk of overloading the muscles. Furthermore, the exercise permits the specific

SUMMARY OF RESULTS OF TRAINING EXPERIMENTS

Age and Sex	Physical Condition	Movement Trained	Joint Position	No. of Training Periods Weekly	Applied Muscle Force in Kg.-m.										Average of 10 Readings		Percentage Increase	
					Average of 150 Readings: Consecutive Groups										Before	After	A	B
21 M.	Normal	Flexion of R. elbow	Flexed to 90°	5	6·31	7·17	7·32	7·69	8·20						5·90	8·41	42	33
20 M.	Normal	Flexion of R. elbow	Flexed to 90°	5	5·86	6·97	7·38	7·34	7·69						5·78	7·86	36	31
22 M.	Normal	Supination of R. hand	−60°*	5	1·74	1·88	1·88	1·85	1·91						1·66	1·97	18	7
21 M.	Normal	Pronation of R. hand	+60°*	5	0·99	1·13	1·27	1·22	1·26						0·90	1·31	46	33
		Pronation of L. hand		5	1·24	1·39	1·40	1·37	1·46						1·29	1·57	22	22
19 M.	Normal	Pronation of R. hand	+60°*	5	0·74	0·84	1·02	1·27	1·21						0·91	1·23	35	82
24 F.	Normal	Extension of R. knee	70° from full extension	3	10·66	11·12	13·35	12·56							10·63	12·28	16	—
		Extension of L. knee		3	10·28	11·48	11·64	11·66							9·41	12·08	27	—
†21 M.	Poliomyelitis 6 months before training	Extension of R. knee	70° from full extension	3	8·77	10·62	12·40	13·41	14·45	14·87	17·71	17·19	18·74	17·90	9·37	19·95	113	123
		Extension of L. knee		3	1·11	1·68	2·94	3·66	4·52	4·73	5·33	5·67	6·64	7·13	0·91	7·33	706	637
†22 M.	Operation for recurrent dislocation of shoulder 6 weeks before training	Abduction of L. shoulder	Arm abducted 15° from side of body	6	2·87	3·20	4·19	4·35 (Average of 10 readings on normal right side—5·69)							2·55	5·12	103	—

* Point of reference (0°) with thumb superior, palm facing medially when forearm horizontal. Plus values indicate angular displacement from this point towards full supination, and minus values towards full pronation.
† Experiment still in progress.

training of only one group of muscles, and the antagonists do not participate directly. In exercises involving alternating movements, unless the strength of the prime movers and antagonists is balanced, it is possible to overwork one or other group. As with all other forms of treatment depending on voluntary effort, success rests on the willingness of the patient to make the greatest possible effort.

Generally, repeated isometric muscular effort tends to be monotonous, perhaps because the patient sees very little result for his exertions, but this apparatus removes this disadvantage by allowing the patient to see his achievement in the form of the deflection of the galvanometer spot.

Another advantage of the apparatus is the measurement and training of muscular contraction before it is strong enough to lift the weight of the limb on which it is acting. The weight of the limb is borne by the apparatus, and any muscular contraction is recorded as a reduction in the effect of this weight on the apparatus. The great sensitivity makes possible a considerable deflection of the spot by even a weak contraction, which, incidentally, acts as an encouragement to the patient.

As the apparatus can be arranged so that only the strength of the muscle group under examination is recorded, the patient can concentrate on contracting this particular group. On the other hand, in a maximum contraction of one group of muscles there is always considerable isometric activity in many others, so that general exercise is provided at the same time.

The clinical use of the apparatus may not be seriously limited in its application to children. A preliminary trial with a boy aged 6 with muscle weakness following poliomyelitis gave such encouraging results that it may be possible to use the apparatus with young patients, especially as attention may be gained and held by modification of the light spot so that a picture is projected on the scale.

Measurement of Maximum Isotonic Contraction

To measure objectively isotonic contraction, the pegs holding the spring-steel bar are removed. A weight exerting the required torque is suspended from the calibration pulley. This torque is resisted initially by placing the pegs in the supporting plate either above or below the bar as required. As the subject develops his contraction, the "static" reading produced by the weight is reduced until it reaches zero, at which point the subject starts to move the weight. The degree of muscular activity can be recorded either as the maximum angular movement achieved or by calculating the work done in lifting the weight. With this method the movement is always against the same force, as the angle of application of the force does not change as the joint is moved.

Measurement of Amplitude of Joint Movement

The apparatus has also been used for the objective measurement of the amplitude of unresisted joint movement. For this purpose the limb is fixed as for measuring the muscle force, but the pegs are removed so that the spindle can rotate freely. The amplitude is read off from the pointer recording the angular position of the spindle.

Advantages and Disadvantages of Strain-gauge Dynamometer

The strain-gauge dynamometer has the following advantages:

1. The apparatus is robust, simple in construction, and requires little maintenance. One of the instruments described has been in more or less constant use during the last four years and has failed only once owing to a break in one of the strain gauges.
2. A wide range of sensitivity can be readily achieved with the same apparatus. The degree of sensitivity can be determined easily and accurately.
3. For practical purposes, the response is linear over the whole range of torques applied.
4. A measure of the muscle strength is immediately obtained.
5. The apparatus measures only the strength of the muscle group being studied and is little influenced by the activity of other groups of muscles.
6. It can be used both for the measurement of muscle strength and for the training of weakened muscles.
7. It can record muscle contraction weaker than that which is capable of producing movement of the limb.
8. For muscle-training purposes the spring-steel bar provides the whole range of resistances that is required.
9. The apparatus can be adapted for measuring the force of isotonic muscle contraction and the amplitude of joint movement.

The following are the disadvantages:

1. It is not easy to obtain automatic permanent records, although this can be effected.
2. The apparatus requires very firm fixing so that it does not move independently of the patient.
3. The fixation of the limb necessitates a number of different supports for different movements. These supports must be carefully fitted to avoid discomfort.
4. Although not bulky, the apparatus does require a certain amount of space, and it is not readily portable.
5. The administration of the tests of muscle strength may be too time-consuming for routine clinical work.

Summary

1. A strain-gauge dynamometer has been constructed for the accurate objective measurement of muscle strength.

2. The underlying principle is that the muscle force developed during voluntary contraction is resisted by a spring-steel bar which bends in proportion to the torque applied. This deformation is measured by the change in electrical resistance of two strain-gauge elements attached to the steel bar.

3. By adjustments to the apparatus, torques developing in different positions of the joint can be determined.

4. The apparatus can also be used for muscle training ; it appears to have particular application to the training of muscles too weak to produce limb movement.

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THE POSTURAL FUNCTION OF THE POPLITEUS MUSCLE

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SEVERAL actions have been ascribed to the popliteus muscle, mainly on the basis of the results of experiments performed on post-mortem material. Thus, it is generally regarded as a medial rotator of the tibia on the femur and as a flexor of the knee-joint, although the latter view has been disputed (Goodsir, 1868; Howat, 1950). In addition, it is said to "unlock" the knee as a preliminary to flexion and, by virtue of its partial attachment to the back of the lateral meniscus (Higgins, 1895; Last, 1950), it is also probably responsible for protecting this cartilage from injury.

The present investigation was prompted by the well-known observation that the popliteal groove on the lateral femoral condyle is occupied by the popliteus tendon in the flexed knee only. This anatomical observation appears to indicate that the muscle is especially active when the knee is flexed.

Material and Methods

Preliminary dissection of three amputation specimens revealed that, although the popliteus muscle is situated deeply in the popliteal fossa, it is accessible for the insertion of needle electrodes. A needle inserted to a depth of 3 cm. in an upward and lateral direction, from a point 8 cm. below the knee-joint line and 1 cm. behind the posterior margin of the subcutaneous surface of the tibia, invariably lies within the muscle.

Electromyographic recordings of the muscle activity were made by means of a concentric needle electrode (S.W.G. 20), a conventional amplifier (time constant = 100 milliseconds), and moving-coil pen recorders (high-frequency response up to 100 cycles). Following insertion of the needle electrode as described, all detected motor unit action potentials were localized by movement of the needle until maximum amplitude of the potentials was obtained. This localization, combined with the limited detection range of the electrodes, ensured that only activity of the popliteus muscle was recorded. Amplifier gains were maintained at a constant level for all recordings.

Results

In all of four adult males the action of the popliteus muscle as a medial rotator of the tibia on the femur was demonstrated (Fig. 1). In three

subjects some activity of the muscle was also recorded at the start of flexion of the knee, but no consistent evidence of continuous muscle activity during flexion or extension of the knee, even against resistance, was obtained.

In all the subjects, on flexing the knee while standing, any activity invariably died away rapidly as flexion proceeded beyond the first two or three degrees, but a full interference pattern of motor unit action potentials was obtained as the knee approached a right-angle. This activity persisted so long as a crouching posture was maintained (Fig. 2), but on straightening the limb it died away (Fig. 3).

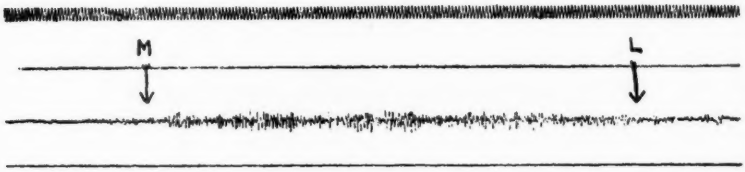

FIG. 1.
Rotation of the flexed tibia. M, start of medial rotation; L, start of lateral rotation.

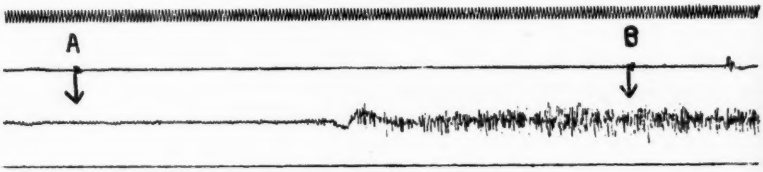

FIG. 2.
Subject standing erect. Knee flexion started at A, crouching posture attained at B. (This subject was exceptional in showing no activity of the popliteus at the beginning of flexion.)

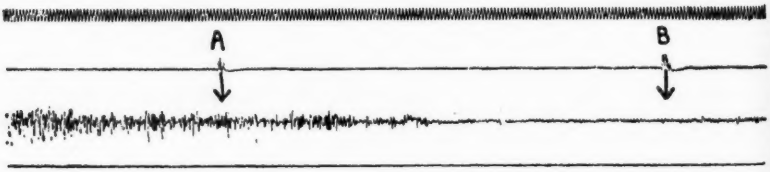

FIG. 3.
Subject crouching. Extension of the knee started at A, erect posture attained at B.

(Calibrations scale: 50 cycles at 1 millivolt.)

Discussion

The generally recognized action of the popliteus muscle as a medial rotator of the tibia and its activity at the start of knee flexion, which can presumably be correlated with the unlocking of the knee-joint, have been confirmed. The continuous motor unit activity of the muscle when the subject maintains a crouching posture by knee flexion was, however, quite unexpected. Consideration of the mechanical factors involved throws some light on this previously unrecognized postural action of the popliteus muscle. Thus, when the knee is bent the weight of the body is directed along the shaft of the femur, and there is therefore a tendency for the femoral condyles to slide forward upon the tibial plateau. Although the posterior cruciate ligament is generally credited with resisting this subluxation, it appears, in fact, that it has the active support of the popliteus to stabilize the knee in this position. Such action is similar to that of the tibialis posterior in supporting the "spring ligament" of the foot.

In the erect posture, muscle action potentials can be consistently detected only in the soleus muscle (Joseph and Nightingale, 1952). In contrast to this relative inactivity, several muscles, including the quadriceps femoris, are in a state of contraction when the knee is bent. However, the only muscle in a position to prevent the femoral condyles from gliding forward on the tibia when a crouching posture is adopted is the popliteus —hence the constant activity detected.

Summary

1. Electromyographic recordings by means of concentric needle electrodes and pen recorders were used to investigate the function of the popliteus muscle in four normal adult males.

2. The action of this muscle as a medial rotator of the knee-joint was confirmed.

3. It was further shown that, during flexion of the knee, the onset is usually accompanied by some activity of the popliteus, which also comes into marked action when flexion is maintained, as in the crouching position.

4. These findings are discussed in the light of the mechanical factors obtaining in the crouching position.

Acknowledgments

Our thanks are due to the medical students who acted as subjects in this investigation.

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CLINICAL REPORTS

MID-TARSAL ARTHROPATHY ASSOCIATED WITH DIABETES MELLITUS

NEUROPATHIC joints are found in association with numerous diseases which may give rise in one way or another to loss of joint sensibility to pain. The more common causes are tabes and syringomyelia; the rarer causes include paraplegia, peripheral neuritis, leprosy, spina bifida, congenital syphilis, and Raynaud's disease.

Evidence of neurological dysfunction is found in 1 in 20 diabetics, with resulting arthropathy in 1 in 1,100 (Rundles, 1945, 1950). This arthropathy of diabetes is found almost exclusively in the joints of the foot or in the ankle.

A case of arthropathy of the mid-tarsal joints associated with diabetes is described below.

W. D. Male aged 45. In 1945 diabetes was diagnosed. He was stabilized on a 2,800 Calorie diet with insulin. Since then he has attended the diabetic clinic regularly. Paraesthesiae in the feet were first noted in 1950. In April, 1951, a corn beneath the head of the 5th right metatarsal became septic. A penetrating ulcer developed and the underlying bone became involved. In spite of prolonged and intensive chemotherapy in hospital it became necessary in September, 1951, to amputate the 5th toe together with the head of the 5th metatarsal. At this time there were no X-ray changes in the mid-tarsal joints. During a stormy post-operative period the diabetes became uncontrolled, and the patient was in coma for several days. Control of the diabetes was re-established and since then it has remained stabilized.

In August, 1952, he was referred to the Department of Physical Medicine because of a "fallen arch" in his right foot; he also complained of heaviness in the legs. On examination, the right foot was enlarged in the region of the base of the 1st metatarsal. There was no tenderness or redness over the swelling, which was bony hard. Cardiovascular system: heart not enlarged; blood pressure 130/80 mm. Hg; peripheral pulses palpable. Central nervous system: left fundus oculi normal, right not clearly seen because of early lens changes; pupils equal, reacting briskly to light; upper limbs normal; in both lower limbs there was absence of deep pain in the Achilles tendons, with gross diminution of sensation to pin-prick, light touch, and hot and cold; vibration sense and joint position sense diminished. Muscle power and bulk normal; knee-jerks diminished, ankle-jerks absent, plantar responses flexor. The skin of the feet was quite dry. Bladder function normal. Other investigations: Wassermann and Kahn reactions negative; radiograph of chest normal; urine green to Benedict's test, no albumin; X-ray examination of feet, see Plate III.

Discussion

It is stated by some authorities (Rundles, 1945; Swarts and Stine, 1948) that diabetic neuropathy differs from other forms of peripheral neuritis in that it is a more generalized pathological process. It affects most of the smaller nerve fibres of the body, including those of the autonomic nervous system. Gastrointestinal disturbances, bladder dysfunction, vasomotor disorders, and abnormalities of sudomotor function have been found in association with diabetic neuropathy in a considerable proportion of cases.

It has been pointed out (Joslin and Root, 1939) that the neuropathy commonly begins or, if already present, rapidly progresses during a period of poor control of the diabetes. It would seem that the smaller nerve fibres of the body are susceptible to damage from the biochemical abnormalities which occur when diabetes is poorly controlled. It is also of interest that the neuropathy may rapidly advance during the initial period of insulin therapy. It is supposed that at this time there is a relative lack of the vitamin-B complex due to a temporary increase in need for these substances (Joliffe, 1943).

Radiological Changes

The radiological changes of diabetic arthropathy are the same as those of any other neuropathic joint, but they tend to occur almost exclusively in the ankle or foot (Bailey and Root, 1942). At first the articulating surfaces show a progressive wearing down but maintain sharp outlines, and joint spaces may be correspondingly increased. Calcium is deposited both within and without the capsule as the changes advance, and this may obscure detail. This calcium may undergo some organization, leaving the bone ends dense and massive, and may form irregular masses of new bone around the shafts. Isolated deposits of extracapsular calcium may be organized into ossicles of ectopic bone. This is the so-called hypertrophic stage. Later, atrophic changes may be seen, especially if the joint disorganization has led to disuse. When this occurs the density and thickness of the bone ends diminish, the articulating surfaces look irregular and frayed, and much of the extracapsular ectopic bone may undergo dissolution (Brailsford, 1945).

Summary

1. A diabetic referred for treatment of a painless "fallen arch" was found to be suffering from neuropathic arthropathy of the mid-tarsal joint.

2. Diabetic neuropathy differs from other forms of peripheral neuritis in that there is usually involvement of the autonomic nervous system.

3. The radiological changes of diabetic arthropathy are similar to those found in other neuropathic joints; they are usually confined to the foot and ankle.

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SYRINGOMYELIA MISDIAGNOSED AS RHEUMATOID ARTHRITIS

IT must be very unusual for a patient with syringomyelia to be treated for twelve years as though he were suffering from rheumatoid arthritis. But this happened in the case described below.

Case History

T. B., a warehouseman aged 46, was admitted to the London Hospital under my care in 1949 with a diagnosis of arthritis. He gave a history of having developed swelling of the small joints of his hands twelve years previously. Shortly afterwards he was treated with "ray therapy". Five years later, as he had not improved, he attended a clinic for rheumatic diseases, where he received much treatment with various forms of physiotherapy, including hydrotherapy. Two years later he started to attend another clinic, where he received long courses of treatment with injections of gold and vaccines. By this time he was getting used to hearing himself described as "suffering from pain and swelling in the small joints of the hands" and he accepted this, although he confessed that his abnormal sensations were those of "pins and needles" and could not be described as pain. He then tried osteopathic treatment without benefit; and as his arthritis progressed he decided to try his luck at the London Hospital.

Examination.—On examination he was found to have extensive but quite painless arthritis of the metacarpo-phalangeal joints, wrists (Plate IV), left elbow, and both shoulder-joints. There was no arthritis of the lower limbs. He was also found to have an extensive whitlow of the left little finger, which had persisted for three months; the terminal phalanx was severely eroded, but it caused him no pain and he paid little attention to it. Neurological investigations showed him to be suffering from syringomyelia with extensive anaesthesia in the upper limbs and spasticity of the lower limbs. Radiological examination of his joints revealed the characteristic changes of Charcot's arthropathy in the various

PLATE III

Skiagram of left foot. The base of the 1st metatarsal is enlarged and its articular surface ill defined. The articular margins of the medial and middle cuneiform bones are also ill defined, but to a lesser degree. The total appearance is that of neuropathic joints.

[*face p. 182.*

PLATE IV

Left hand and wrist (above) and right hand and wrist (below) in a case of syringomyelia misdiagnosed as rheumatoid arthritis.

joints and also in two of the cervical intervertebral joints. He was also suffering from Paget's disease.

Subsequent History.—The patient was given a course of deep X-ray therapy to the cervical region in order to attempt to check the progress of the disease. His employers proved most helpful in adjusting his employment to his disability. He left hospital after seven weeks greatly cheered if not physically improved. A year later he was readmitted because of lobar pneumonia, from which he made a good recovery. He now attends regularly as an out-patient; his condition has not changed much.

Discussion

Neither Comroe (1949) nor Copeman (1948) mentions syringomyelia with multiple Charcot's joints in the differential diagnosis of rheumatoid arthritis.

In the case reported here the patient, on being questioned more closely, revealed that while he was under treatment with vaccines a clinical assistant had queried the diagnosis and suggested syringomyelia, only to be promptly contradicted by the "specialist", who told him sharply that there was no doubt about the diagnosis. The possibility of the coexistence of rheumatoid arthritis and syringomyelia had to be considered. But this was ruled out by the complete absence of arthritis in the lower limbs, and muscle biopsy revealed no focal aggregations of round cells as described by Desmarais, Gibson, and Kersley (1948).

The only moral to be drawn from this history is the old one that arthritis cannot be accepted at its face value and that careful routine examination is as important in arthritis as in any other disease.

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NEW APPLIANCES

A HYDRAULICALLY OPERATED, SELF-PROPELLING CHAIR

THE chair described and illustrated has been designed for patients whose disability makes it difficult or impossible for them to get from the sitting to the standing position and vice versa. It has been used for six months in a Department of Physical Medicine, and has proved its value in the management of paraplegics, hemiplegics, and patients with peripheral neuritis or anterior poliomyelitis with severe involvement of the lower limbs. With this chair such patients can rapidly raise themselves from, or lower themselves into, a sitting position, independent of help and with the minimum expenditure of energy.

Basic Structure

The chair is constructed as follows: (*a*) a box-type chassis; (*b*) a movable seat and back rest; (*c*) a hydraulic jack and pump unit; and (*d*) an automatic foot-rest.

The Chassis

The box-frame chassis is mounted on 24-inch pneumatic-tyred, self-propelling wheels at the back, and 5-inch sprung wheels at the front. The wooden chassis (Fig. 1, A), is 15 inches high, 20½ inches wide, and 18 inches deep, and is composed of 2 × 1 inch wooden battens. The lower sides of the chassis are extended forward for 12 inches to act as mountings for the small front wheels. The large hand-propelled wheels are mounted on a square-section axle screwed to the lower members of the chassis at the back.

The Seat and Back-rest

The seat, which is 2 inches higher at the front than at the back to prevent patients slipping forward, is hinged to the top edge of the box chassis at the front (Fig. 1, B), the back being hinged to the back of the seat (Fig. 1, C) at its lowest point. The arm-rests are carried upwards from the front of the box chassis for 9 inches, and are hinged to D (Fig. 1), and to the back of the seat 10½ inches from the lowest point of the seat at the back (Fig. 1, E). This method of hingeing allows the back-rest to remain perpendicular as the seat rises upwards.

The Jack

The standard hydraulic jack made by Smith's Jacking Systems Limited, type No. X67269, is incorporated as the lifting mechanism. This jack (Fig. 1, F) is mounted, by means of a collar and swivel pins, between two wooden battens attached to the lower members of the chassis, the upper end being

mounted on a swivelling metal block screwed to the base of the seat. A standard pump control unit and fluid reservoir are mounted on the right-hand side of the chair, just in front of the large back wheel. An extension piece has been welded to the pump control unit to bring the valve to an

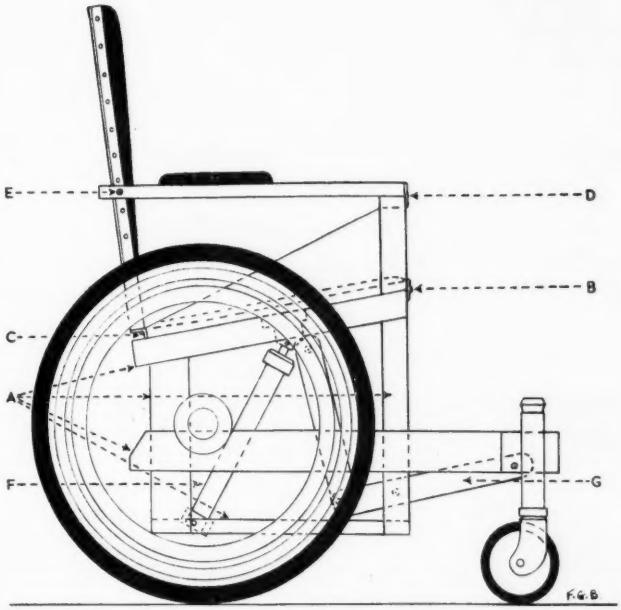


FIG. 1.
Side elevation of tilting chair (semi-diagrammatic).

accessible position beside the arm-rest. The standard operating lever supplied with the jack is also placed convenient to the hand, just outside and on a level with the arm-rest.

The Foot-rest

A plain foot-rest (Fig. 1, G) is mounted on levers in such a way that when the seat is in the raised position the foot-rest lies flat on the floor, and with the seat in its normal position the foot-rest automatically rises to $6\frac{1}{2}$ inches above floor level, and remains parallel to the floor while the chair is wheeled. By closing the valve and pumping, the patient can rapidly raise himself to an erect position. When he leans backwards against the chair and slightly opens the relief valve, the chair gradually lowers him to a normal sitting position.

Plate V shows the chair closed for the patient to sit in (A) and with the seat raised (B).

New Appliances

On the occasion of his official opening of the Spastic Unit at Swindon, in October, 1952, Lord Horder inspected the prototype chair and gave permission for it to be named after him.

Acknowledgments

I wish to acknowledge the excellent workmanship put into the chair by Mr. Smith, who is employed in my department as a joiner.

The Swindon Hospital Management Committee made available the funds for the building of the prototype illustrated, which has cost approximately £30, including the hydraulic pump and wheels.

The Plessey Company Limited of Swindon made the swivel attachments, and Smith's Jacking Systems Limited have supplied me with much technical help in the choice of the jack.

The self-propelling pneumatic-tyred wheels were supplied by Tan-Sad Limited, Great Bridge, Staffs, and the small spring-loaded swivelling castors with rubber-tyred wheels were supplied by the Homa Engineering Company, Limited, Cosby, Leicester.

J. B. STEWART

THE GUTHRIE-SMITH BED-CHAIR

THE Guthrie-Smith bed-chair (Plate VI) has been designed to assist in the nursing of patients who are likely to be confined to bed for a long time and would otherwise be completely helpless. It is constructed on the lever principle, and with its use patients in bed need no longer remain static. The supports are so arranged that not only is the body held securely and in a good position, but the mobility which it allows will assist the circulation, especially of the knees and legs (thus lessening the risk of thrombosis), and, as slumping down in the bed is prevented, good respiratory movement also can be maintained. The leverage of the chair is such that the patient can be lifted and turned easily so that the legs hang over the side of the bed. This requires little effort on the part of the patient or of the nurse.

With the foot-rest in position, a fixed point for counter-pressure is available; the patient can be encouraged to stretch down with the leg and back muscles so that by degrees he can train himself to lift his pelvis off the bed to allow the placing of an air ring or a bedpan under him.

With the bed-chair rehabilitation exercises of all kinds can be carried out, from simple intrinsic movements of the muscles of the feet and ankles to full stretching of the erector spinae muscles; also exercises for the strengthening of the gluteal and quadriceps muscles.

I have found this appliance useful for the nursing of (1) rheumatic and hemiplegic patients in the general hospital wards, (2) the elderly sick in the "chronic" hospital, and (3) the patient with rheumatoid arthritis who is being cared for at home by an elderly nurse or companion. My only criticism is that, although it is of great help in getting the patient out of bed, it is of little use in getting him back.

FRANCIS J. BACH

PLATE V

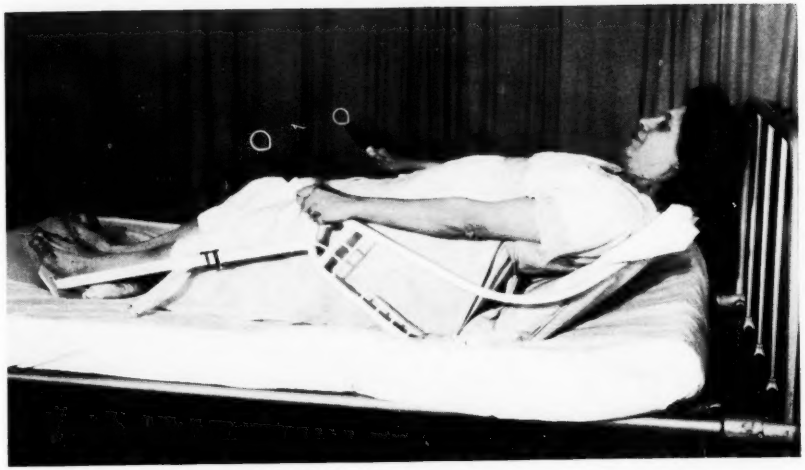
PLATE V

A, The tilting chair, side view.

B, With seat raised to allow patient to stand.

[face p. 186.

PLATE VI



The Guthrie-Smith bed-chair.

ABSTRACTS OF THE LITERATURE

Localization of Erythemal Processes caused by Ultra-violet Light in Human Skin. P. B. ROTTIER and J. A. M. MULLINK. *Nature, Lond.*, 1952, **170**, 574.

The authors outline experimental methods and observations in a study on the effects of the two main erythema-producing regions of the ultra-violet ray spectrum—2,970 and 2,500 Å—and add their own deductions, which are of fundamental importance. With these two portions of the spectrum they irradiated both normal skin and skin stripped of its horny layer. Whereas erythemal reactions were readily obtained on the normal skin with both wave bands, the radiations in the neighbourhood of 2,500 Å did not, in comparable doses, produce reactions on the treated skin.

The authors conclude that in the case of the 2,500 Å wave-band the absorption by the most superficial layer of the skin is responsible for, and essential to, the production of the erythema. They suggest the elaboration of photolysable substances as an explanation.

The implications are obvious and their views may well afford an answer to the recurring question of the relative value of various sources of radiations used for therapeutic purposes.

P. BAUWENS

An Electromyographic Study of the Trapezius Muscle. M. M. WIEDENBAUER and O. A. MORTENSEN. *Amer. J. phys. Med.*, 1952, **31**, 363.

Eleven men served as subjects for this study, in which 950 electromyographic tracings were made from eight points overlying the trapezius muscle. The action potentials were recorded with an electrocardiograph through pairs of skin electrodes placed parallel to underlying muscle fibres. During elevation of the arm greatest activity was found in the upper fibres ; during retraction of the shoulders, in the middle and lower fibres; during flexion, in the lower half of the muscle. Greatest trapezius activity was recorded during shoulder abduction.

SIDNEY LICHT

Effect of Contrast Baths on the Vasomotor Response of Rheumatoid Arthritis Patients. F. J. FRICKE and J. W. GERSTEN. *Arch. phys. Med.*, 1952, **33**, 210.

The authors found that the hand skin temperature of patients with rheumatoid arthritis was about the same as that of healthy subjects, but that when the hands of arthritics were immersed in water at 15° C. for one minute, the skin temperature fell further and faster than did that of normal subjects. By treating the arthritic patients with contrast baths for a month the depth of fall diminished but the return to pre-test temperature remained slow.

SIDNEY LICHT

Modern Trends in Hydrotherapy. T. G. REAH. *Med. Press*, 1952, **228**, 47.

The author gives a most useful résumé of the value of hydrotherapy, stressing the cardinal principles of treatment by immersion baths in deep pools. Conforming to Archimedes' law, gravity is almost banished or greatly reduced in such pools, thus allowing weak muscles to perform more easily and inefficient joints to become more efficient. The stimulating effects of douche and spray are

mentioned, but these obviously have a very limited application. Contrast baths (hot and cold) are said to be helpful in rheumatoid arthritis and useful as a domiciliary routine—a routine which, incidentally, is too seldom prescribed. However, many readers may question the advisability of using them in the treatment of Raynaud's disease and peripheral vascular occlusive disease.

A. B. COYER

Physical Treatment of Osteo-arthritis in the Smaller Joints. D. WILSON. *Med. Press*, 1952, **228**, 44.

The author discusses the problem of those—and there are many—who suffer from the pain and disability derived from osteo-arthritis of the smaller joints of the hands, feet, and spine. He stresses the cardinal features of treatment by controlled rest and movement. This may sound paradoxical, but the author further explains the need for rest when pain is paramount, and the need for movements when these are possible. It is significant that this review mentions the use of almost all known methods of physical treatment which aim at obtaining vasodilatation around the joint, counter irritation, or the pain-relieving properties of heat. Short-wave diathermy is unquestionably most valuable; it is a proven source of penetrating heat. But has ultrasonics been proved to be beneficial ? As to galvanism and associated iontophoretic methods, are they any more effective than advice on weight-bearing and lin. meth. sal. and tabs. codein. co. ? They are certainly much less economic as regards time and transport and the use of skilled personnel.

The value of manipulative measures, especially in the commonly affected spinal apophysial joints, is referred to. Improvement may be dramatic, especially in the cervical variety, which has recently been given prominence under the classification of cervical spondylosis.

A. B. COYER

The Action of Ultrasonic Energy on the Autonomic Nervous System. F. S. ZACH. *Brit. J. phys. Med.*, 1952, **15**, 256.

The author quotes from Sturn (1946) : " In all kinds of radiation, irrespective of the wave-length and the area irradiated, and independently of the absorption of radiation, what happens in the brain-stem is the same." In other words, the response of the autonomic nervous system to a stimulus is independent of the kind of stimulus which is applied at any given time. He states that there are two opposing views on ultrasonic therapy : (1) that ultrasonic action is a novel form of localized diathermy ; and (2) that the essential factors are the mechanical components (including cellular pulsation and consequently altered processes of diffusion, osmosis and catalysis). The author of this paper considers that the decisive factor in ultrasonic treatment is most likely to be the reactivity of autonomic functioning and an alteration in autonomic tonus. In brief, he considers that ultrasonic energy may be regarded as a non-specific stimulus to the autonomic nervous system, evoking both local and general reactions which, in view of their relatively rapid course, must be assumed to traverse neural pathways. He presents the result of his clinical and laboratory experience.

(Though this paper is difficult to understand, it should be read by those interested in this new and widely advertised form of physical treatment.)

FRANCIS J. BACH

Abstracts of the Literature

Klinische Resultate bei Bestrahlung der Hypothalamus-Region mit Ultra- und Mikrokurzwellen (Radar) mit besonderer Bezugnahme auf die Wirkung der Polyarthritis chronica gegenüber. GUNNAR KELSTRUP. *Z. Rheumaforsch.*, 1952, **11**, 211.

This is one of several papers that have appeared in recent years on this subject. The author describes his findings in 39 cases of rheumatoid arthritis in which the hypothalamic region was irradiated with ultra-short waves and microwaves. He reports that, in addition to clinical improvement, there was a fall in eosinophil count following treatment. He considers the results to be encouraging, and invites critical assessment of the method by other workers.

(In the opinion of the abstracter, there are dangers associated with this form of treatment. But if recent reports on the use of cortisone and A.C.T.H., and the opinion that when a patient responds to that form of treatment there is always a reduction in the number of circulating eosinophils, are accepted, then treatment with ultra-short waves should be carefully studied and compared with the results obtained with the various drugs and endocrine preparations that are used in the treatment of rheumatic patients.)

FRANCIS J. BACH

Tables for Vertebral Elongation in the Treatment of Sciatica. E. NEUWIRTH, WINIFRED HILDE, and R. CAMPBELL. *Arch. phys. Med.*, 1952, **33**, 455.

Traction devices for skeletal complaints were used before the time of Hippocrates, whose descriptions were advanced and complete. There are many ancient drawings of traction devices for dislocation, fracture, and spinal curvature. Since sciatic pain has long been considered the result of vertebral pressure on nerve roots, there is little wonder that many attempts have been made by bone-setters, chiropractors, and physicians to separate the vertebrae for short or long periods in an attempt to relieve pain. In recent times traction has had its greatest popularity in France, where Dr. Neuwirth saw the Godet table in 1950. He brought one back with him to the United States and modified it. Traction is obtained by tilting the foot end of the table down while the patient is suspended from above by a Sayre type collar. Traction is also obtainable with thoracic and pelvic corsets. Of 13 patients with sciatica treated in this way, 8 recovered completely.

SIDNEY LICHT

Some Effects of Cerebral Diathermy on Normal Adults. E. K. STONER and H. SHAPIRO. *Arch. phys. Med.*, 1952, **33**, 272.

Electrode pads measuring 5 by 8 inches were bandaged to each side of the head of eight normal adults. The electrodes were connected to a diathermy machine rated at 27 megacycles, and current to tolerance was admitted to the cranium for 20 minutes or more. There was no significant change in systemic temperature, blood pressure, pulse, or respiration. Most subjects complained of drowsiness during the application, which was followed by fatigue after the current was discontinued.

SIDNEY LICHT

BOOK REVIEW

The Cure of Rheumatoid Arthritis and Related Conditions by Physical Medicine. By JOSEPH ECHTMAN, M.D. New York: Herald Square Press, Inc. Pp. 251. $6.00.

Dr. Echtman claims to " cure " arthritis. He urges his readers to discard what he describes as " the primitive methods of treatment "—heat, massage, exercises, and stretching—and insists that only three pieces of apparatus are necessary for the treatment of all the forms of arthritis discussed in his book. These are: low-volt current (galvanic and sine wave) apparatus, an ultra-violet lamp, and long-wave diathermy.

The reviewer is not in a position to judge the result of Dr. Echtman's methods in his clinical practice. Having read this book, however, he is left with the impression that Dr. Echtman's knowledge of rheumatic diseases is somewhat limited. It is perfectly true, as Lord Horder said at a recent Congress, that unanimity does not necessarily mean that you have arrived at the truth. The methods of treatment that we teach at the present time, certainly have their limitations and their faults. It is hard to believe, however, that the methods described by Dr. Echtman are as successful as those in common use.

This book does teach us a lesson. Specialization, as we see it, is not so much a separate part of medicine as the whole of medicine seen from a particular point of view. In this we have a particular point of view combined with little appreciation of medicine as a whole. It is not a book that should be read by the young man who is studying physical medicine; it may have some interest to advanced students who are preparing a thesis on the history of physical medicine and wish to explore the byways as well as the highways of the subject. These are the wanderings of a keen but single-track mind. At one stage of his journey through this book your reviewer had happy recollections of his voyage on Emett's Railway in Battersea Park.

F. J. BACH

It is with deep regret that we record the sudden death of ALFRED JOHN MARTIN, which occurred on January 6, 1953, at the early age of 43. Dr. Martin, who was Physician in Physical Medicine to the Royal Free Hospital, was a member of the Council of the British Association of Physical Medicine